ENERGY FROM AI: USHERING IN A NEW FRONTIER IN SMART HYDROPOWER OPERATIONS

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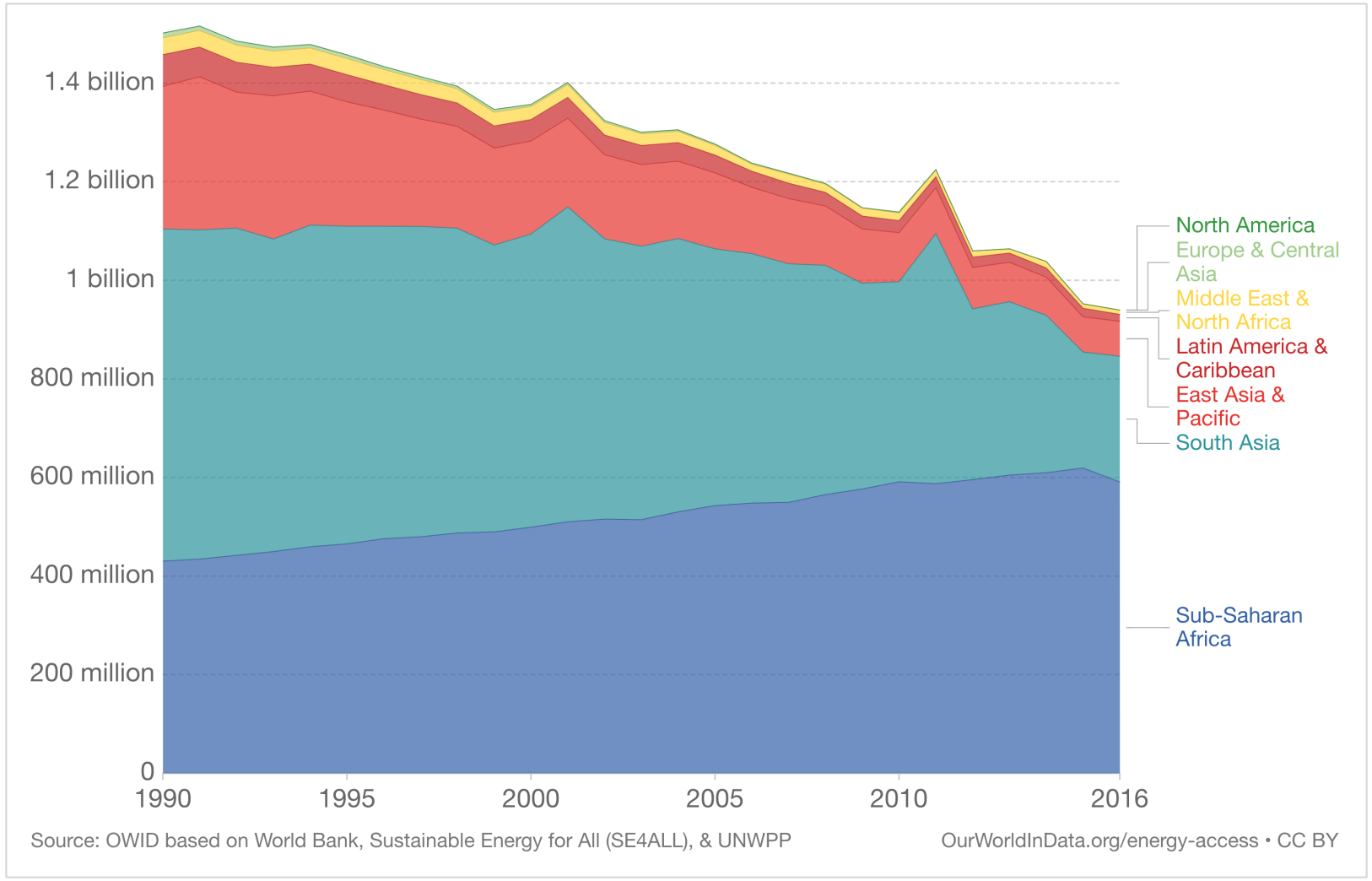
BILLIONS LACK ACCESS TO SAFE ENERGY



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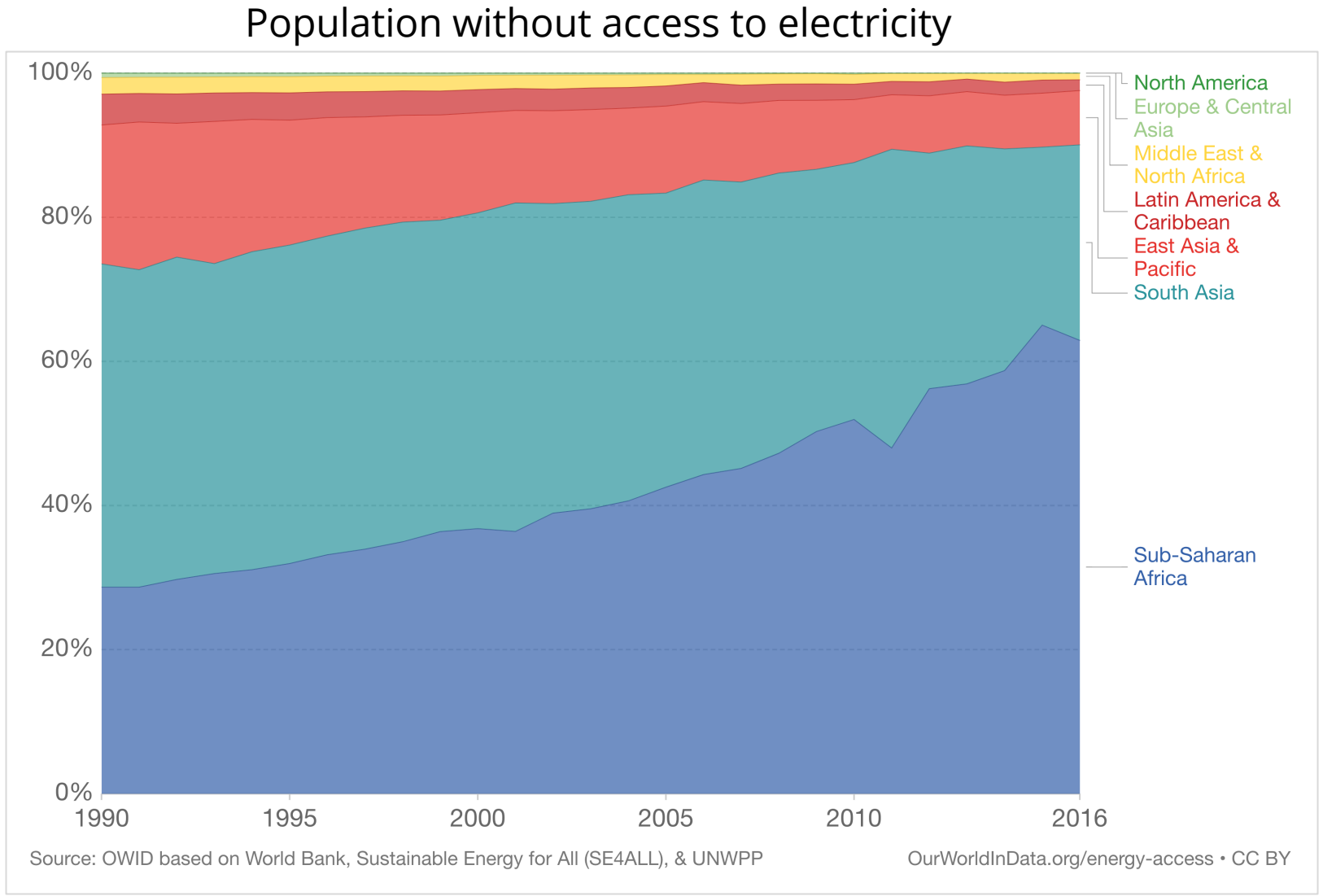
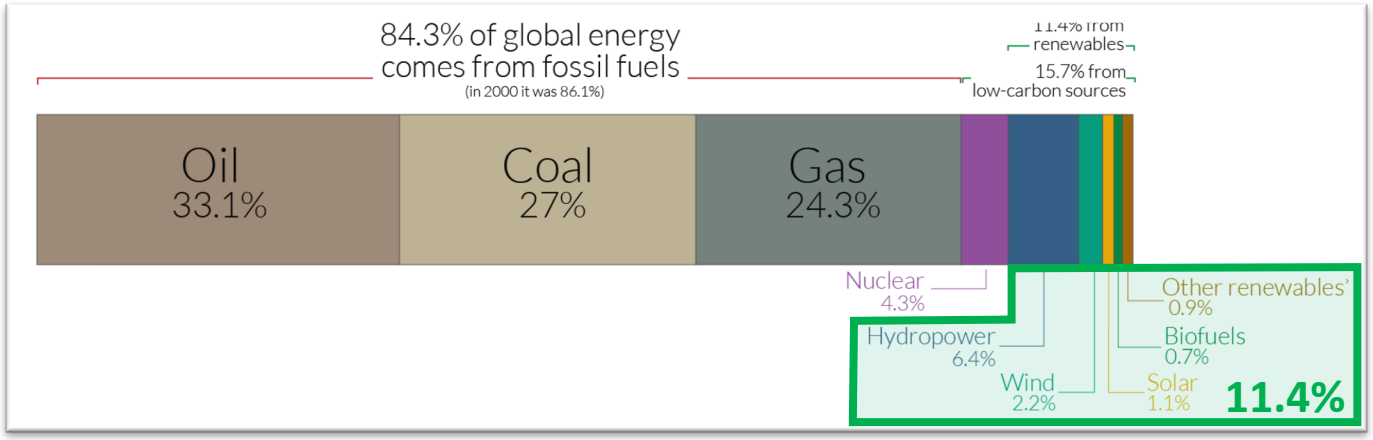
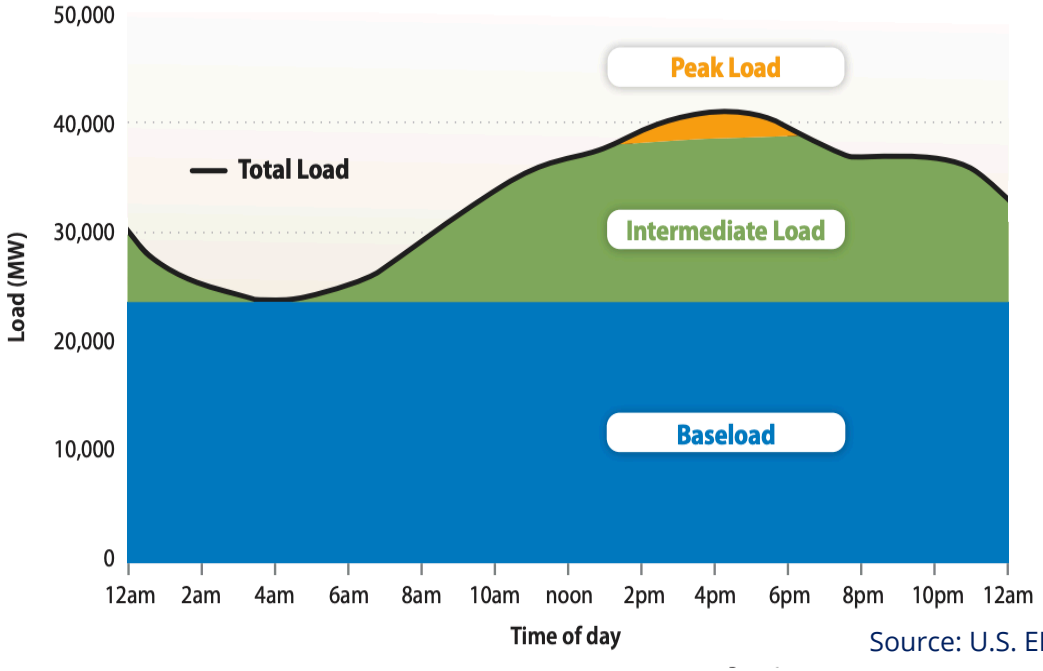


WHY HYDROPOWER?



Pathway to cleaner solutions



Source: U.S. EIA

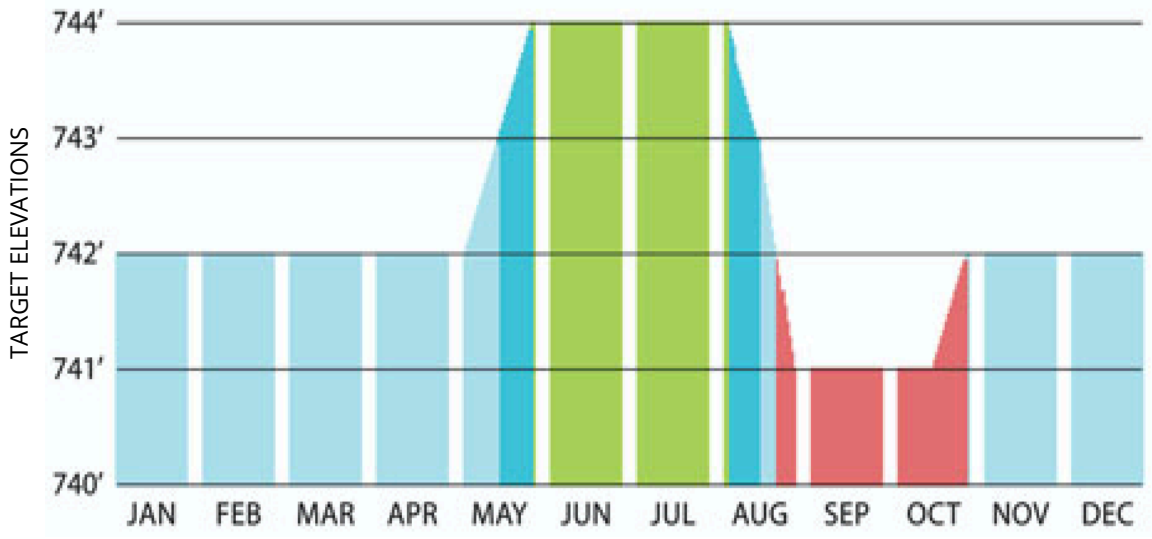
Typical summer day load for CA

COSTS!

https://riverwatch.eu/en/general/news/ngos-call-eu-end-support-new-hydropower

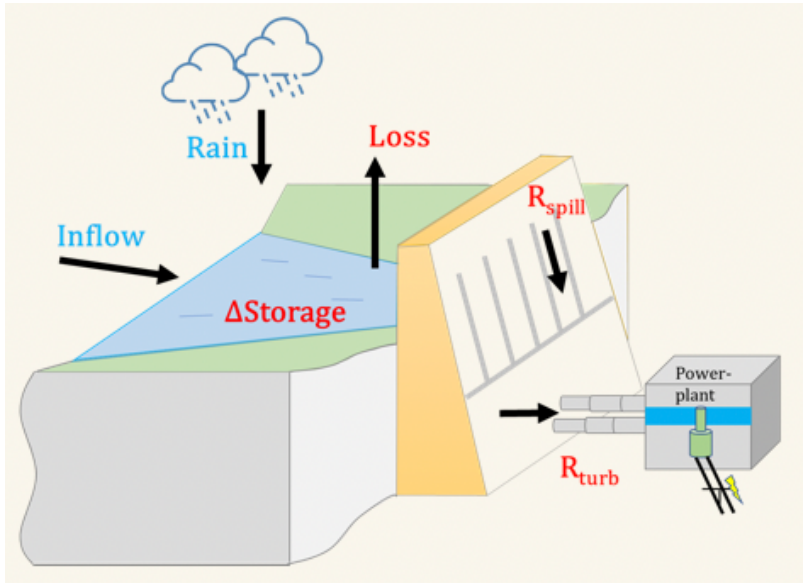
https://alanhesse.com/

DAM OPERATIONS

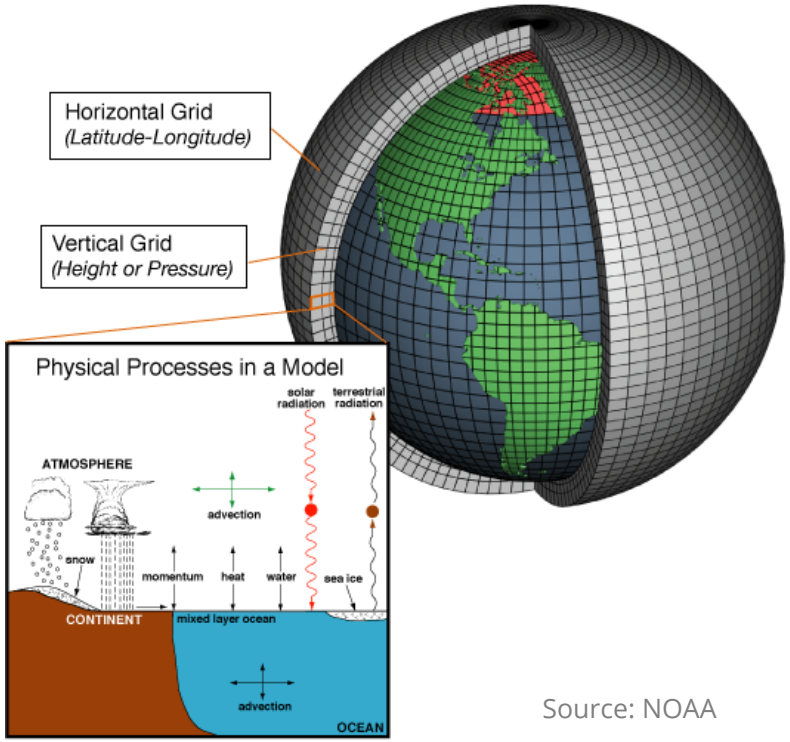


Rule Curve for Pensacola Dam, OK

Source: Grand River Dam Authority (GRDA)

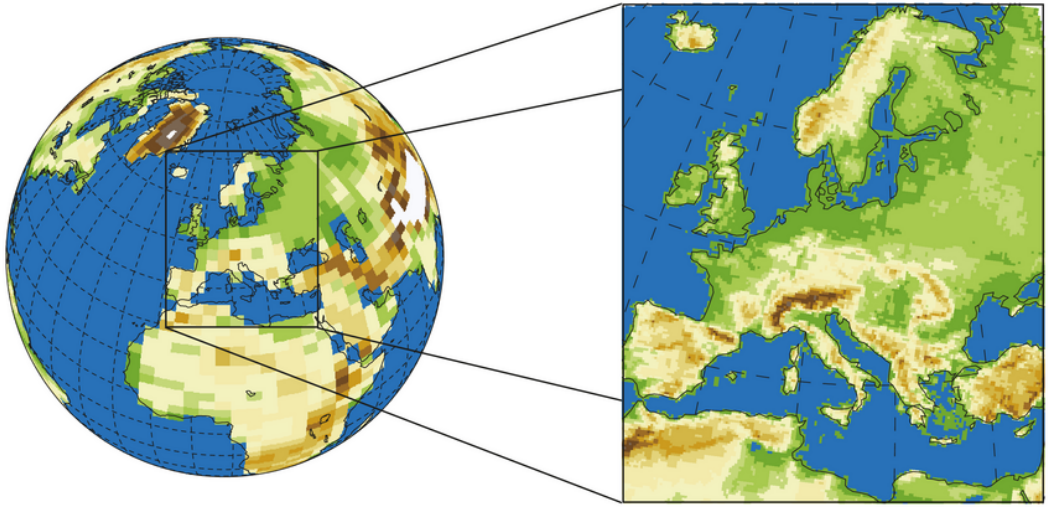


NUMERICAL WEATHER PREDICTION

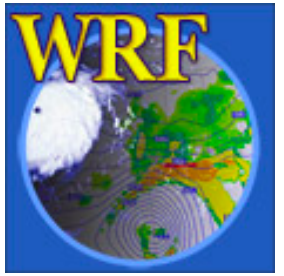


Source: NOAA

Dynamic Downscaling

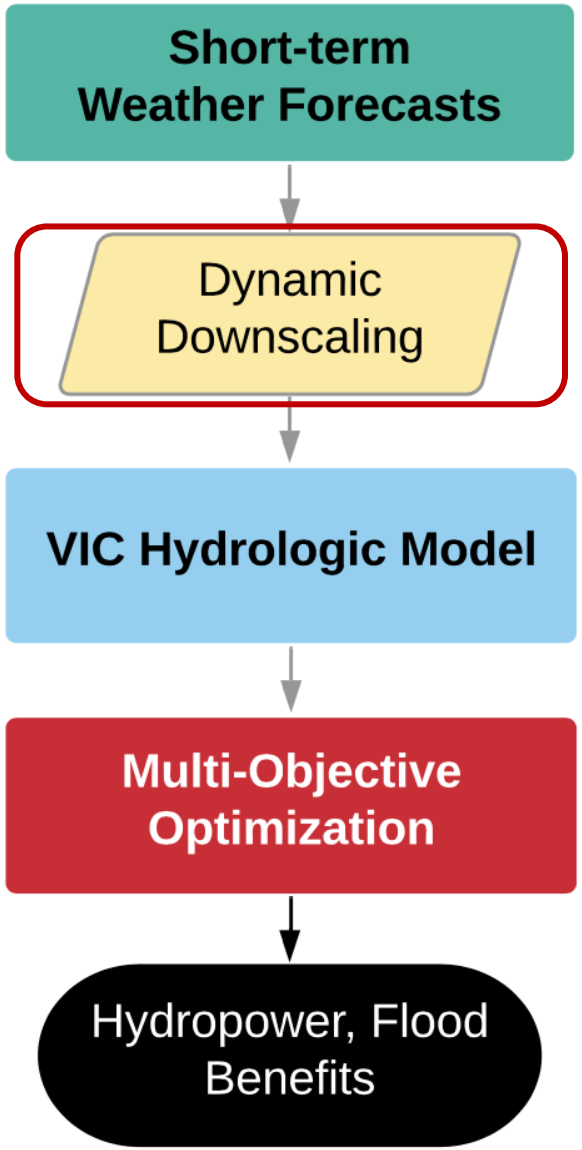


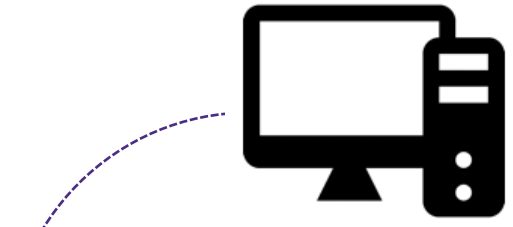
Requires **downscaling** for meaningful hydrological modeling over reservoir basins



Source: UCAR

WORKFLOW





9 hours

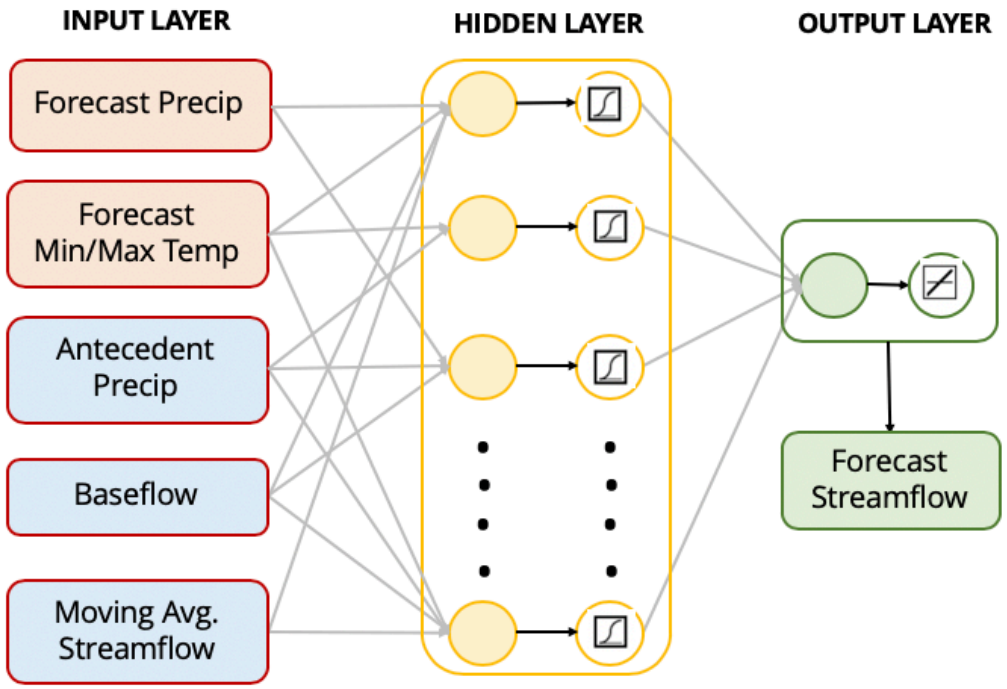
WRF processing time for 15-day forecasts

**personal machine*

- ↑ processing time
- ↑ computational resources
- Forecasts need high skill

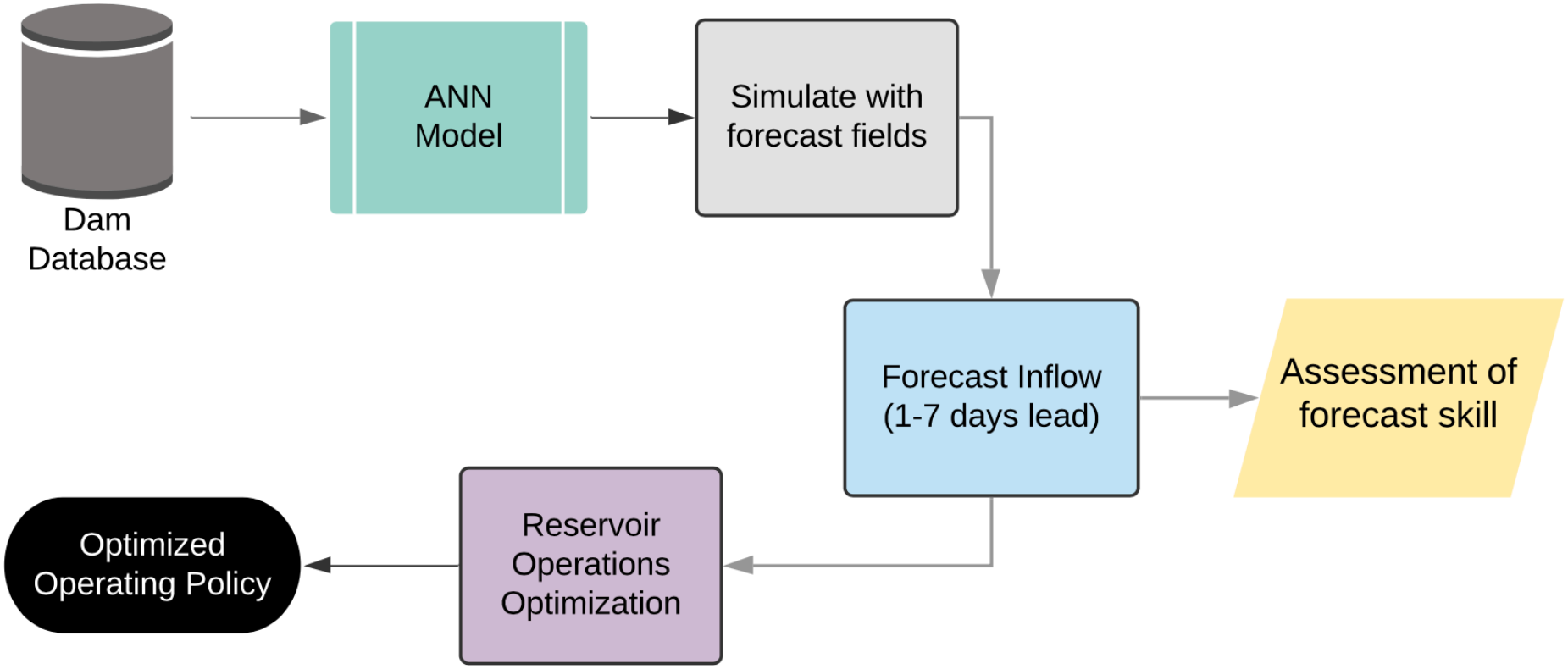
ARTIFICIAL NEURAL NETWORKS

- Capture nonlinearity
- Fast once trained
- Rapid **multi-year** historical assessment
- Inputs based on basin's hydrologic processes

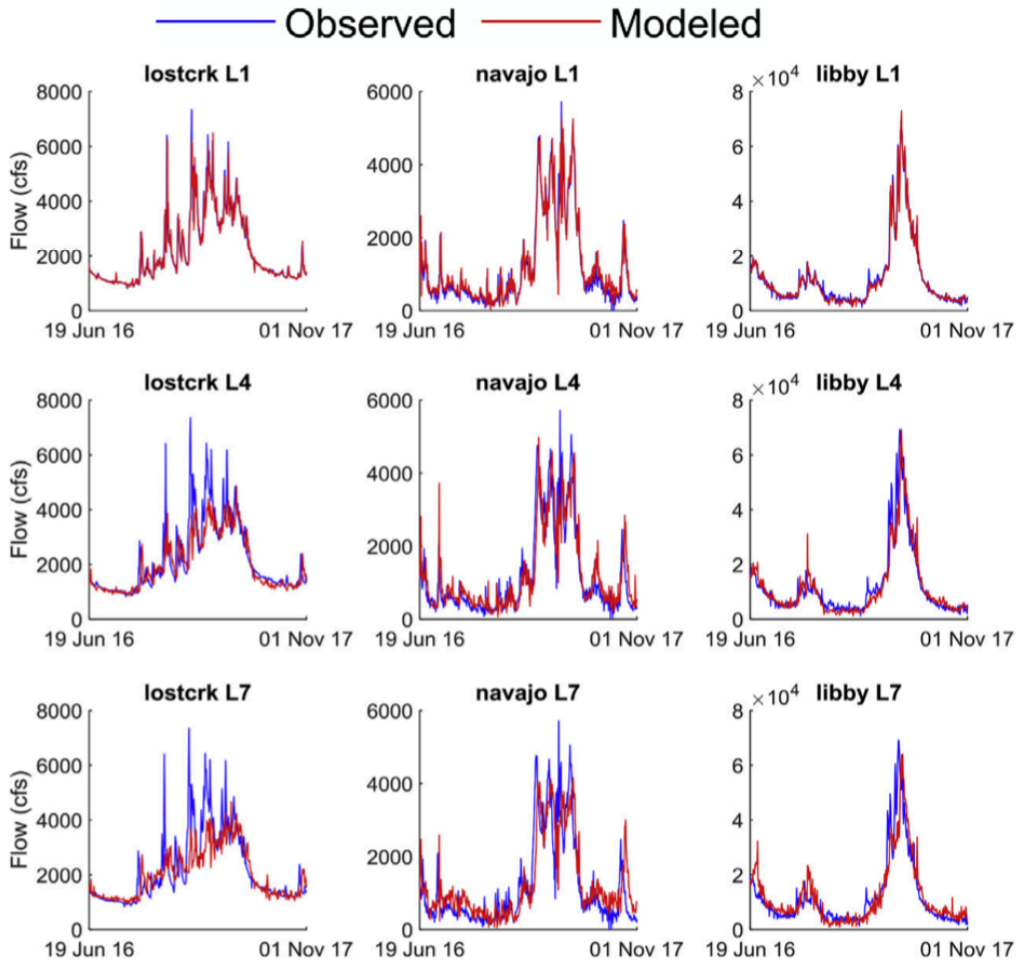


3-Layered Feedforward ANN Architecture

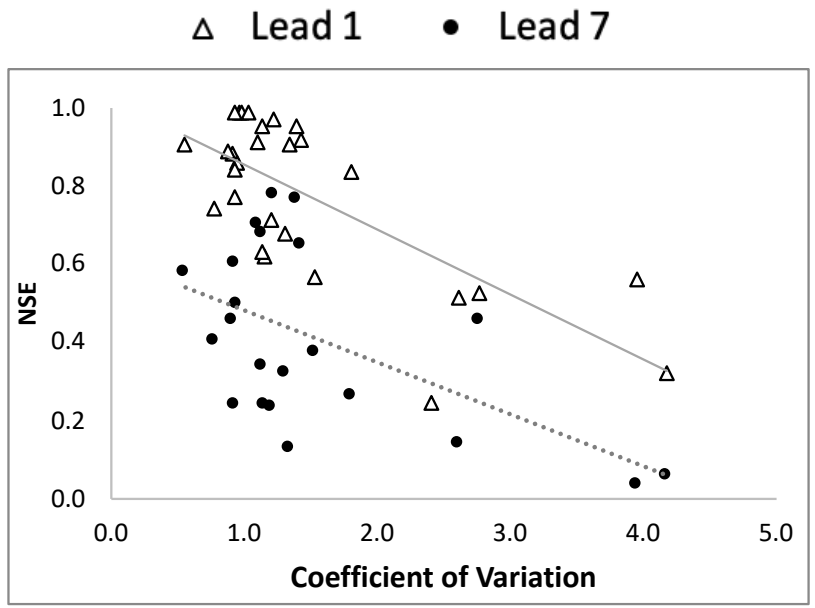
AI-BASED SOLUTION



RESULTS – FORECAST SKILL

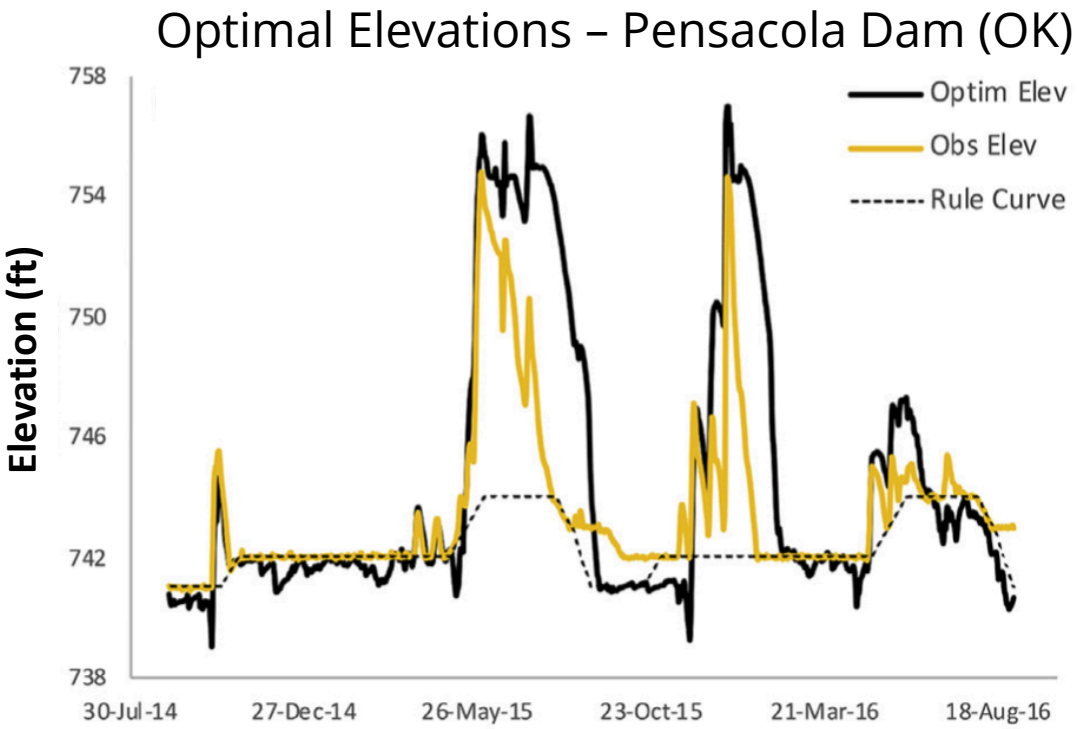


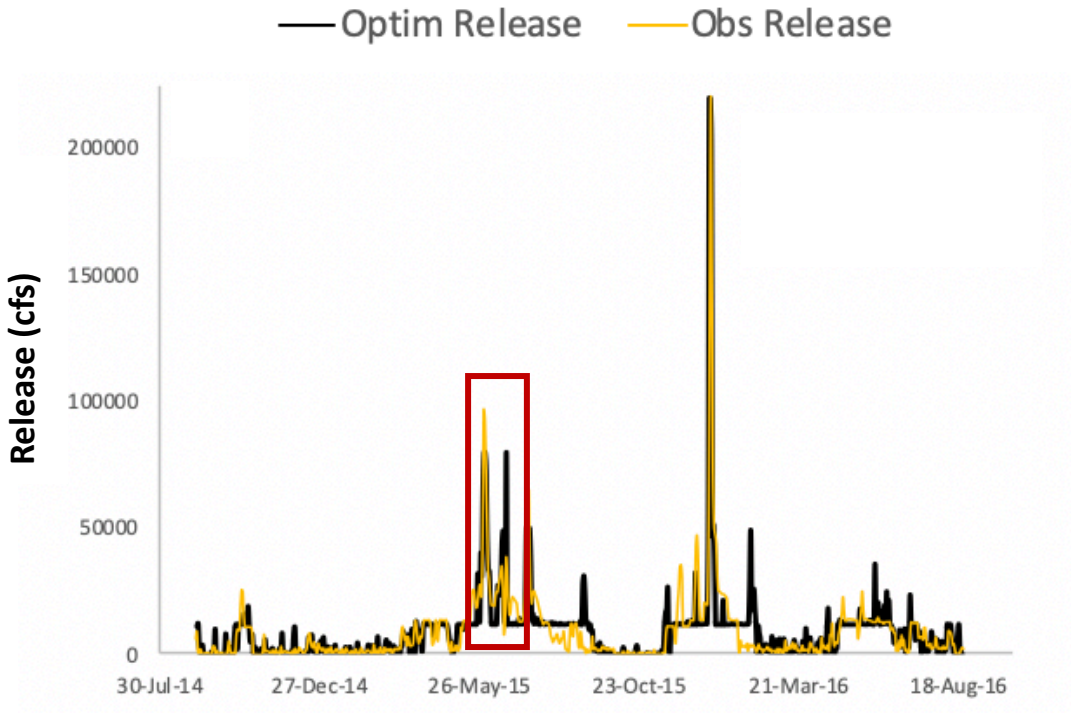
NSE at 7-day >0.5 for 48% of sites



Increase in skill with:
↓ flow variability
↑ drainage area

OPTIMIZATION WITH ANN FORECASTS





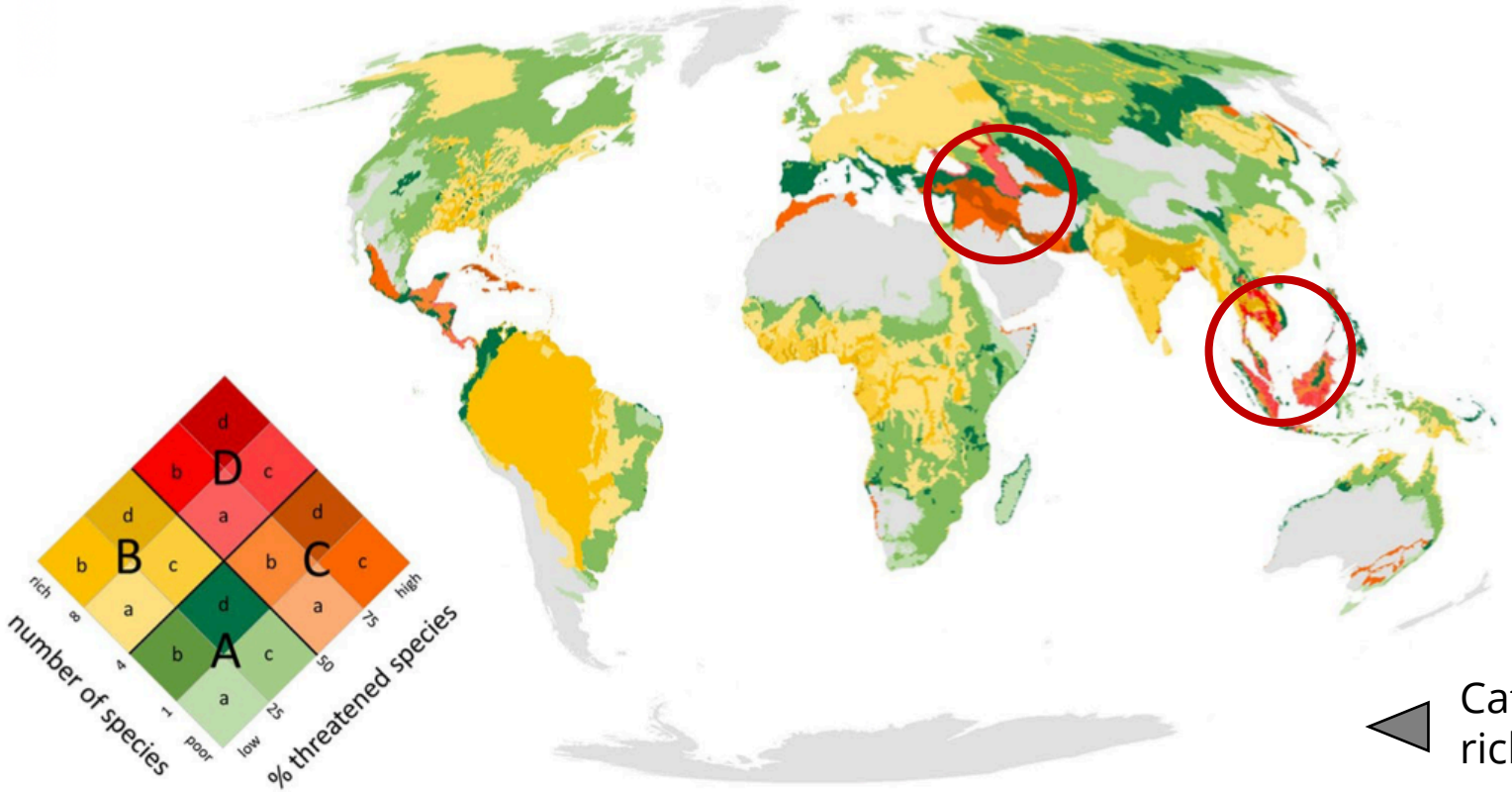
Hydropower Benefits

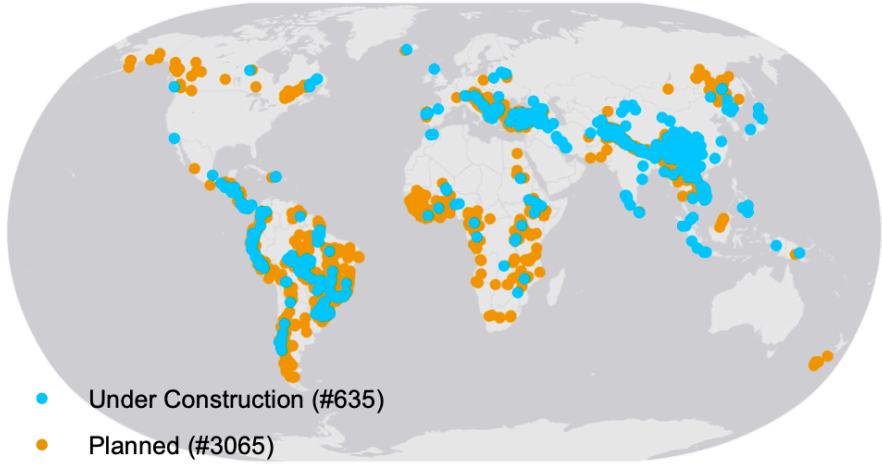
47,253 MWh ≡ 45,530 households for 1 month

Flood Control Benefits

Reduction in peak release: **18%**

WHAT ABOUT THE FUTURE?





Data: Zarfl et al., 2015

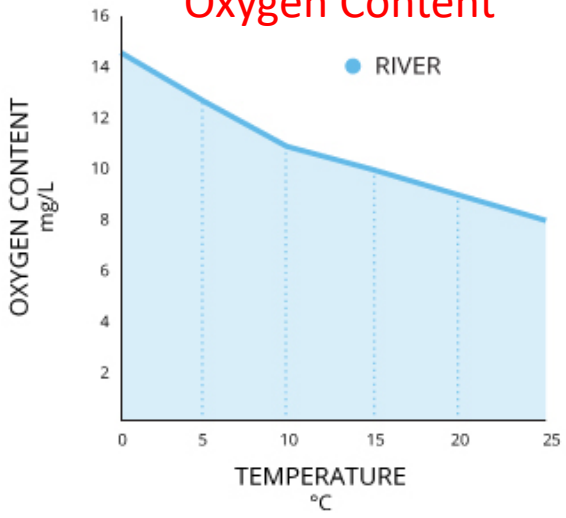
Catchments according to species richness and threat status

Majority of future dams will be built in latitudes with high share of **threatened species**

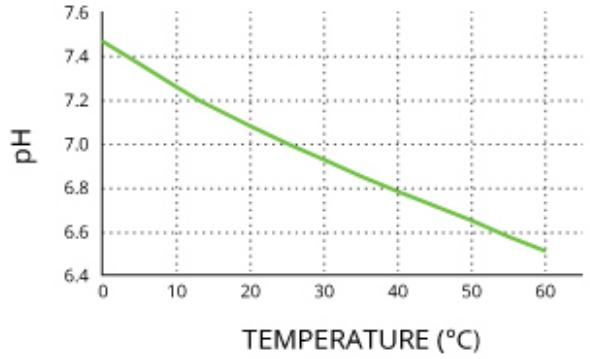
Zarfl et al. 2019. Future large hydropower dams impact global freshwater megafauna. *Scientific Reports*, *9*(1), pp.1-10.

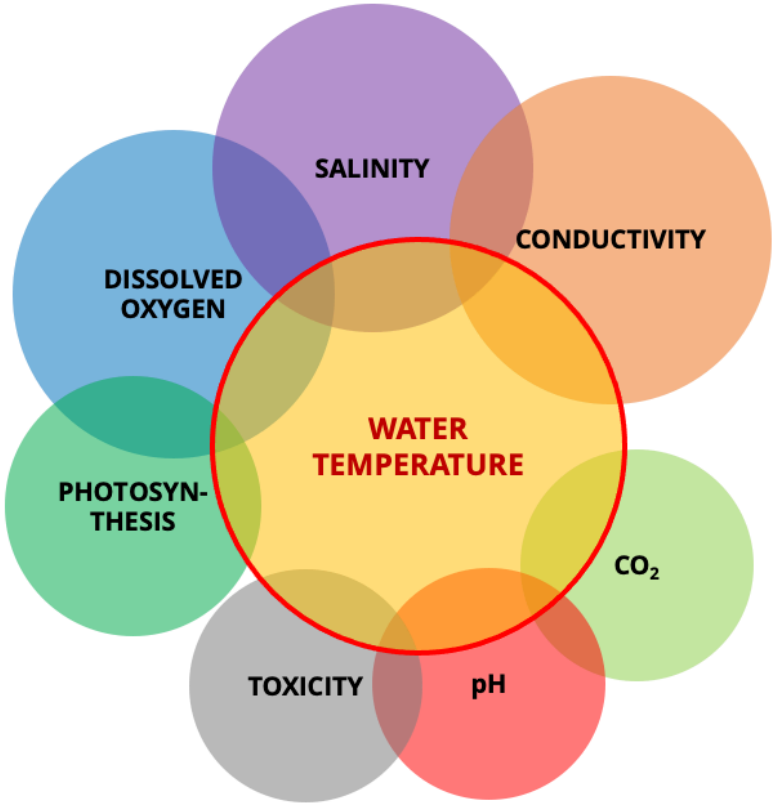
ROLE OF WATER TEMPERATURE

Oxygen Content

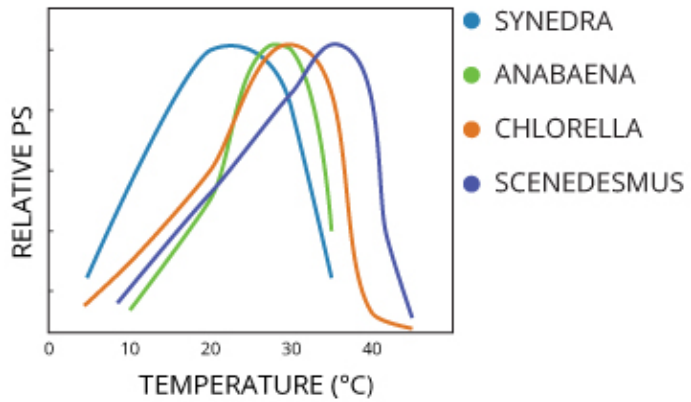


pH

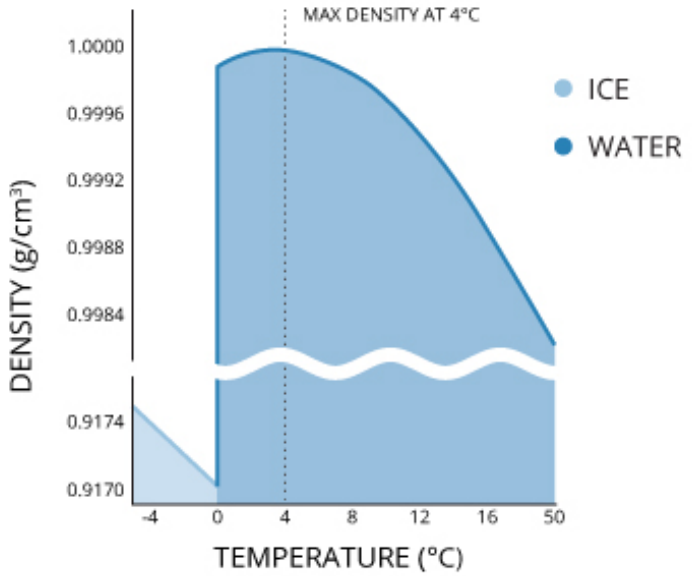




Photosynthesis Rate



Density



Credit: Fondriest Environmental, Inc. “Water Temperature.” Fundamentals of Environmental Measurements. 7 Feb. 2014.

FUTURIST THERMAL IMPACT MODEL

FUture Temperatures Using River hISTory

U.S. ▶ 

Derive thermal impacts of existing dams

Develop relationship with dam characteristics, climate, hydrology

Developing Countries ▶ 

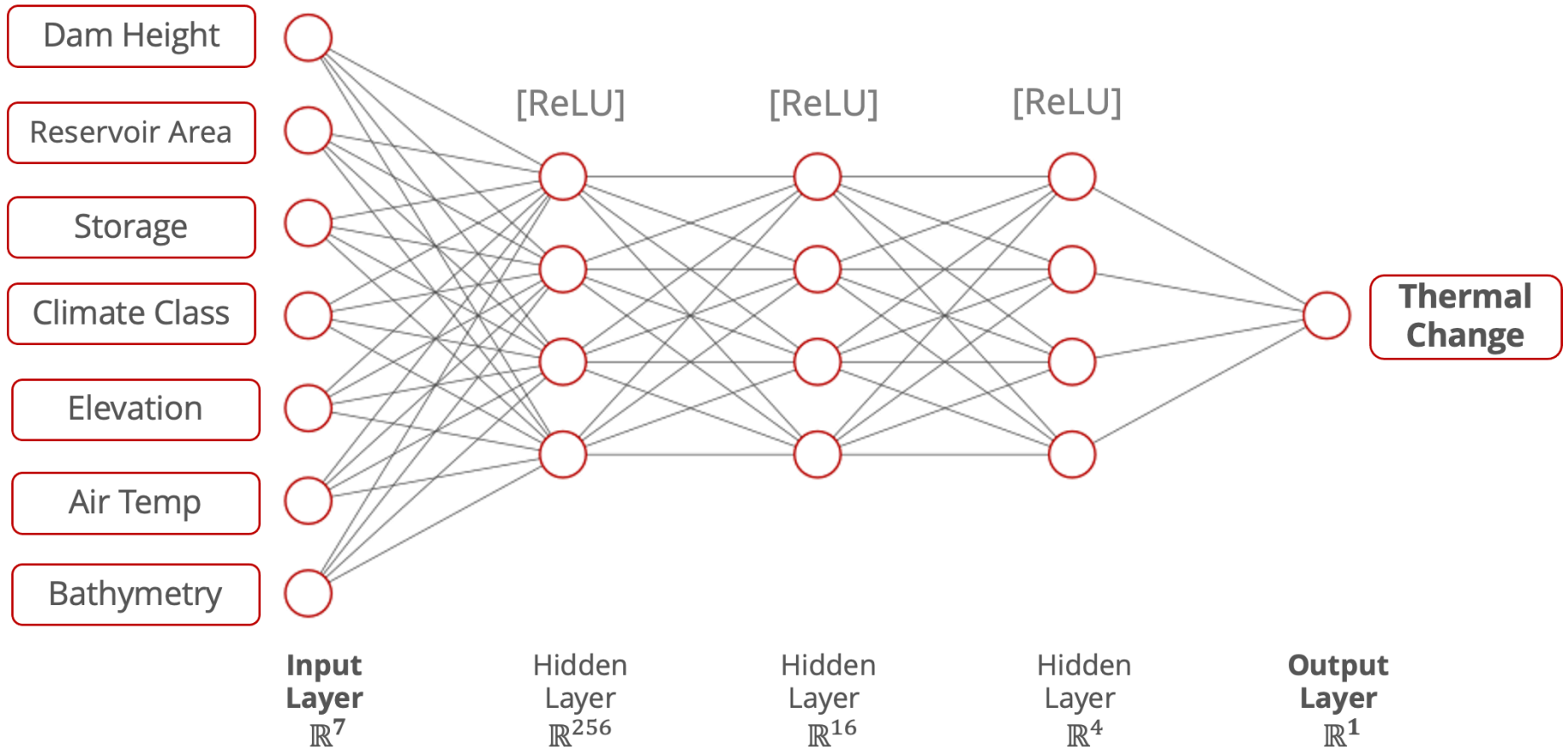
Validate model in ungauged locations

Global New Sites ▶ 

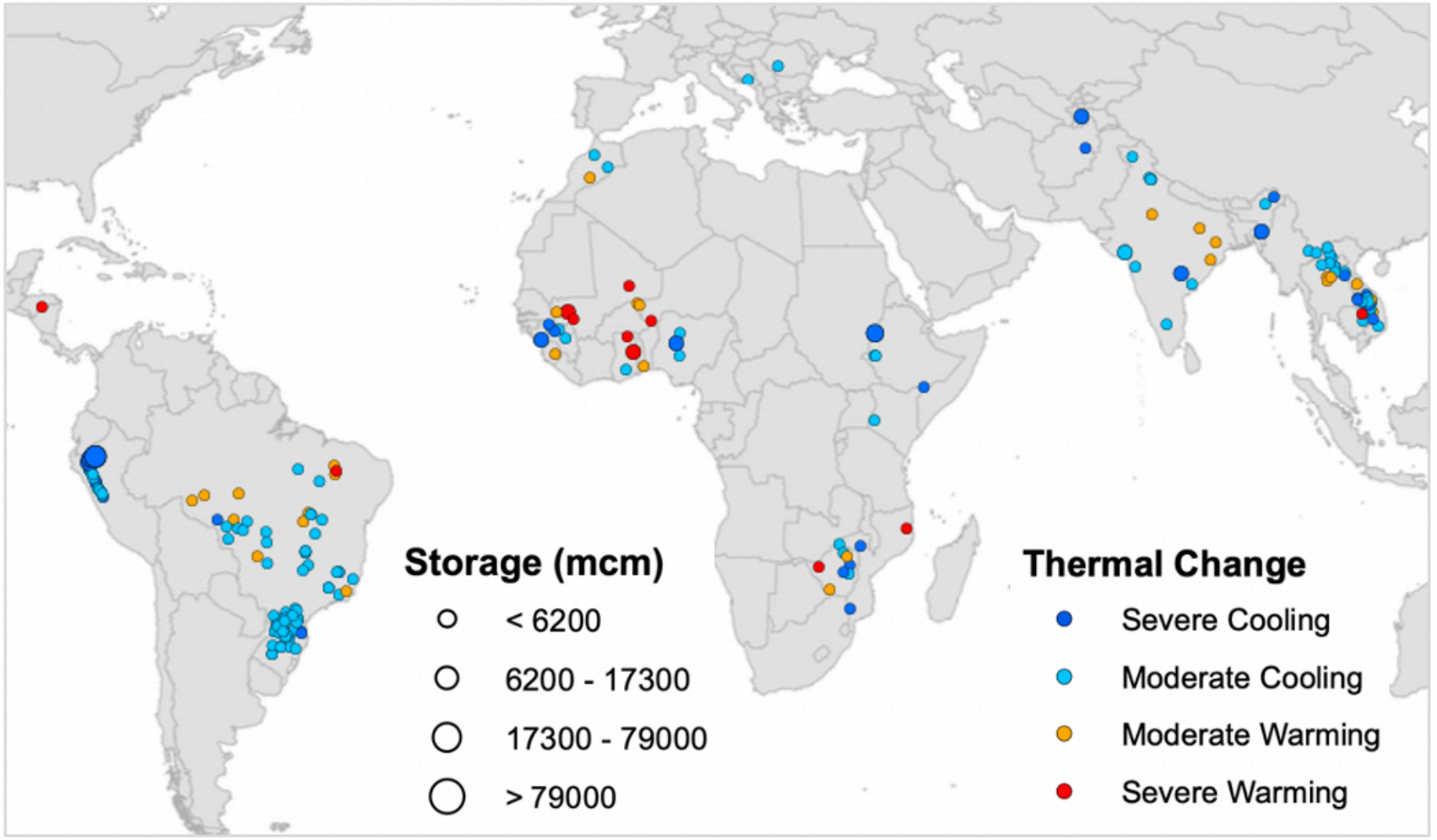
Predict impact of future hydropower dams

FUTURIST THERMAL IMPACT MODEL

Artificial Neural Network Model



THERMAL IMPACT OF FUTURE DAMS



Likely thermal impacts of future hydropower dams (Jun-Aug)

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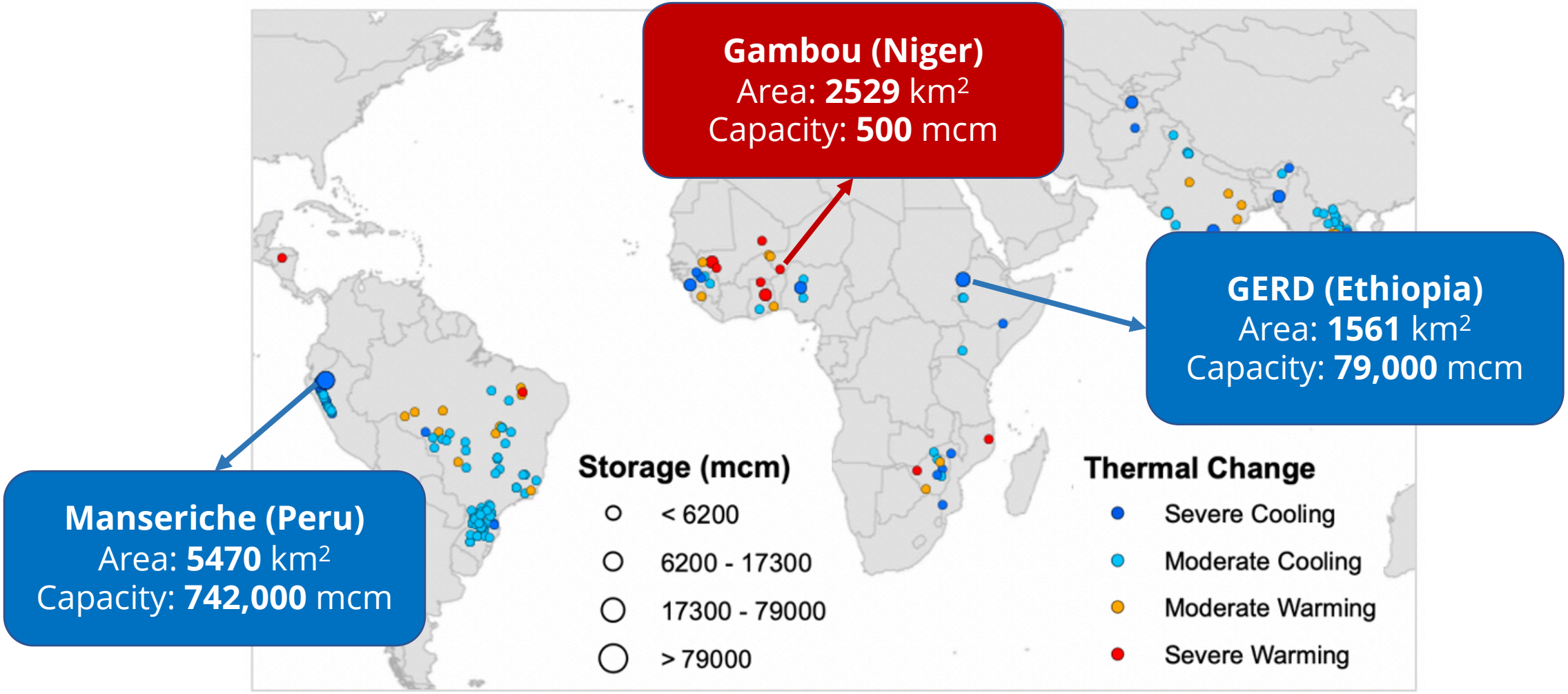
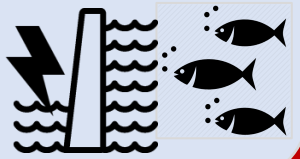
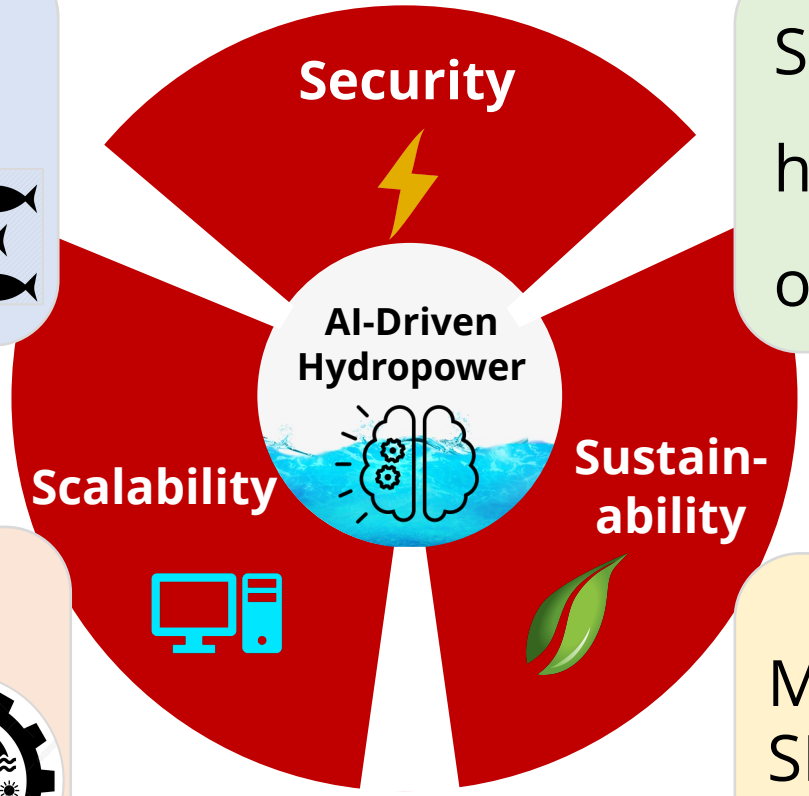


Likely thermal impacts of future hydropower dams (Jun-Aug)

KEY TAKEAWAYS

Less dams, more energy, better ecosystem outcomes





Stronger engagement with hydropower dam operators

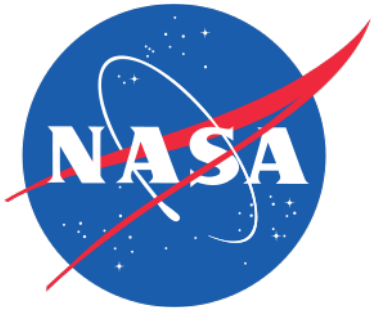
Smart grid operations using wind, solar and hydropower

Meet UN SDG

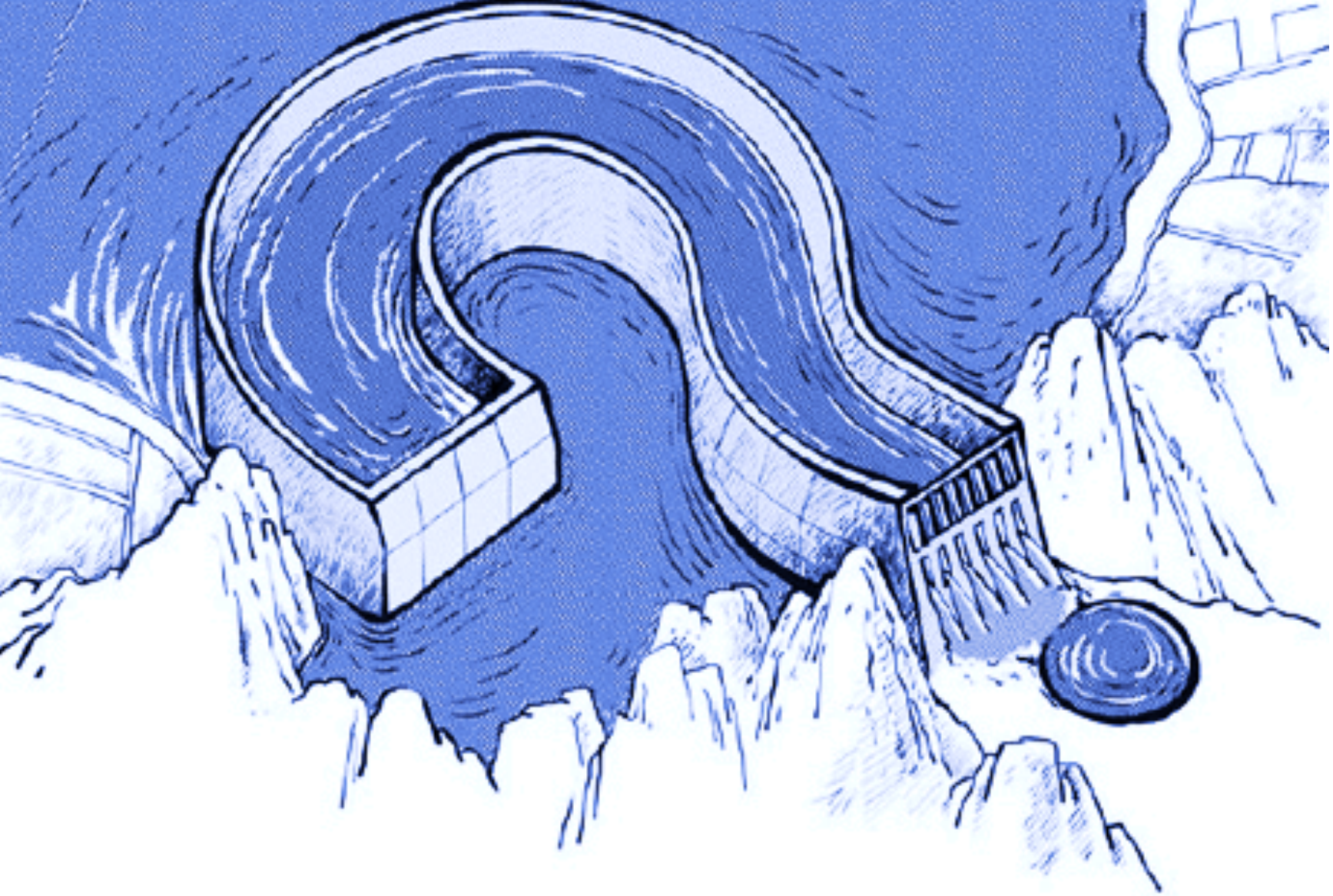
ACKNOWLEDGMENTS

NASA Applied Science Program grant in Water Resources

NASA Applied Sciences SERVIR grant



THE IVANHOE FOUNDATION



THANKS

QUESTIONS?

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